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ABSTRACT

Concept mapping typically refers to the graphic representation of concepts and their interrelationships. In this instance, concept mapping is used as a means for assessing an individual's conceptual understanding of a curricular topic. In a series of studies with teacher trainees, emphasis was on determining whether concept maps have regular features which are quantifiable and which change as a function of instruction. Differences were found on number of items (differentiation) on pre and post maps for topics which were the focus of course instruction but not for topics for which there was not instruction. The internal contents of maps were highly idiosyncratic and, although in the absence of instruction, there were not significant changes in differentiation or overall complexity, there were changes in the specific content included. Nevertheless, the maps appeared to be excellent diagnostic devices for determining individuals' conceptions regarding topics such as "teaching," "classroom management," "documentation of children's gains." Differences were also found on differentiation scores and on the number of subordinate levels portrayed between groups of teacher trainees with differing amounts of education for the topic "teaching." Years of experience for inservice teachers, however, were not related to scores derived from maps. (Author)

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Concept Mapping for Individual Assessment

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ABSTRACT

Concept mapping typically refers to the graphic representation of concepts and their interrelationships. In this instance, concept mapping is used as a means for assessing an individual's conceptual understanding of a curricular topic. In a series of studies with teacher trainees, emphasis was on determining whether concept maps have regular features which are quantifiable and which change as a function of instruction. Differences were found on number of items (differentiation) on pre and post maps for topics which were the focus of course instruction but not for topics for which there was not instruction. The internal contents of maps were highly idiosyncratic and, although in the absence of instruction, there were not significant changes in differentiation or overall complexity, there were changes in the specific content included. Nevertheless, the maps appeared to be excellent diagnostic devices for determining individuals' conceptions regarding topics such as "teaching," "classroom management," "documentation of children's gains."

Differences were also found on differentiation scores and on the number of subordinate levels portrayed between groups of teacher trainees with differing amounts of education for the topic "teaching." Years of experience for inservice teachers, however, were not related to scores derived from maps.

The term concept mapping has appeared in recent professional literature with related but differing applications. It typically refers to the technique of graphically representing concepts and their interrelationships and has been suggested as a means for increasing reading comprehension (Hanf, 1971; Rauch and Ellenworth, 1980), as a study strategy for college students (Reigeluth, 1979) and as a strategy for analyzing conceptual structure of a subject of interest e.g., program evaluation (Gowin and Green), and course content (Stewart et al., 1979; Diekhoff and Diekhoff, 1982).

For the purposes of the studies herein reported, concept mapping has been defined as a process by which individuals may illustrate their respective understandings of a given content area by letting their thoughts flow freely and hierarchially organizing in chart form these free associations around the content label and indicating with connecting lines, interrelationships between ideas. Superordinate-subordinate relationships, interrelationships among subordinate concepts, as well as content diversity, are graphically presented. In our work, we are primarily focusing on the usefulness of concept mapping for assessing individuals' current degree of concept organization and concept differentiation around given topics. Novak (1981) and associates are pursuing a similar research agenda with the expectation that concept mapping can serve as a powerful tool for ascertaining what students know in a new area and for assessing student achievement. This type of investigation is within the genre of what Sternberg (1981) describes as a "cognitive-contents" approach to psychometric testing. This is based on the idea that a locus of difference between more and less able

people relevant to a given task is the extent to which they have meaningfully organized information in long-term memory in a way that makes it readily available. By obtaining and contrasting concept maps on selected topics from persons with differing experiences, we are attempting to determine the viability of this approach for individual assessment.

Several aspects of concept mapping are of potential interest. The specific content and positioning of that content on an individual's map provide useful information on thinking relative to that topic. We are also interested in the following types of quantitative measures--(a) the number of discrete entries included on an individual's concept map (b) the number of subordinate levels employed and (c) the number of distinct item streams (superordinate concepts) and their interrelationships. Theoretical support for examining differentiation and conceptual hierarchies comes from several sources.

Theoretical Background

Lewin (1975) described development as increasing differentiation in skills, emotions, needs and knowledge as evidenced in more varied behaviors. According to Lewin, "...the hierarchial organization of the life space increases with age. Such an increase can be observed within the inner psychological regions and in the relation of the psychological environment to the inner personal regions" (1951, p. 110). Werner (1978) similarly suggested that thinking processes follow certain developmental regularities involving increased differentiation and hierarchial organization. He distinguished between two types of differentiation--one a vertical differentiation which involves a filling

out and one a horizontal differentiation which involves a reorganizing. He claimed, "Wherever development occurs, it proceeds from a state of relative lack of differentiation to a state of increased differentiation articulation and hierarchic integration" (1978, p. 86).

Many others, including Ausubel (1963, 1978), also argue that learning as well as development occurs according to principles of progressive differentiation and integrative reconciliation. Building on Ausubel's distinction, rote learning is defined by Novak as new information "arbitrarily stored in a cognitive structure of...associated with weakly differentiated concepts at low levels of abstractness and inclusiveness" (1977, p. 113). Meaningful learning, on the other hand, is said to occur when new information is subsumed into a larger structure which relates it to other concepts. Ausubel's central pedagogic advice is "find out what the learner knows and teach him or her accordingly" (1978, p. 378). The learner's concept map may provide an efficient graphic representation of what he/she knows about a concept area so that effective teaching can proceed.

As Novak (1977) points out, standardized achievement or intelligence measures are inadequate for telling about "the specific conceptual hierarchies an individual possesses...(or) the extent of differentiation of concepts in these hierarchies" (p. 114). What is needed is a way of determining the nature and complexity of this semantic encoding by which individuals represent meaning in memory. Traditional item sampling methods do not reveal what the individual is capable of reconstructing from memory without prompts regarding a subject of interest. It has been well-established that recall memory is different from recognition

memory (Kintsch, 1974, p. 94); recall requires "the internal recording of experiences upon which recognition is based, plus...the organization of these experiences into memory nets." It is the format of these "memory nets" and their contents that the instructor of Ausubel's persuasion seeks, since effectiveness of instruction is thought to be dependent on whether new learning tasks may be predictably adapted to existing concepts in the learner's cognitive structure to which they are relatable (Ausubel, 1963, p. 89).

Ausubel (1978) proposes that "with increased age, concepts tend (1) to consist of higher-order abstractions, (2) to exhibit more precision as well as differentiation,; (3) to be acquired more through concept assimilation than through concept formation; (4) to be accompanied by awareness of the conceptualizing operations involved" (p.87).

We make the assumption that relevant dimensions regarding a concept area can be brought into awareness to be graphically portrayed in a way which reflects the organization and complexity of functional memory structures. Though it has been suggested by Novak (1979; 1981) and Stewart et al., (1979) that mapping could be used to examine cognitive structure variables and as diagnostic instruments in planning for instruction, little research has investigated these claims. The research that has been reported has focused only on scientific disciplines.

In a series of studies we are investigating--

1. whether concept maps have regular features from which reliable measures of differentiation or structural organization may be derived.

2. whether persons of varying degrees of training and/or experience produce qualitatively or quantitatively different concept maps.
3. whether concept maps reflect increased knowledge resulting from instructional interventions.
4. whether scores derived from concept maps reflect competence as assessed via other indices relating to the same concept area.

Study 1

The intent of Study 1 was to determine whether changes in students' knowledge and understanding of a topic are reflected in concept mapping before and after the study of that topic, and if so, to analyze the nature of these changes.

Subjects

The subjects of this initial study were five graduate students, Master's degree candidates, enrolled in a summer session seminar on documentation of young children's learning taught by one of the investigators. The students' respective specialities were library science, special education, home economics education, developmental psychology and elementary education. Two had classroom teaching experience; the others had not. The sample in this study and in the three subsequent studies were predominantly female. To our knowledge none had previously done concept mapping.

Procedure

On the first day of the seminar the students were shown a complex concept map prepared by the instructor on the topic of sailing. They

were then directed to portray their concepts of "documentation" as the term would be applied to "the means for documenting the extent to which children change over time as either a function of development or learning." Blank sheets, 12" x 20", were provided and ample class time was available; completion of the maps was accomplished within approximately 20 minutes by all students. Although the maps were collected by the instructor, they were not further discussed with the students.

On the last day of the six-week seminar for their final examination, the students were provided with their initial concept map, a blank 12" x 20" sheet and another sheet on which the following was written:

NOTE

> Examine the concept map you completed on June 30th to refresh your memory of the way you thought about documentation of children's learning and development at that point. Then, through writing, listing, outlining and/or some kind of graphic portrayal, show how you are now thinking about documentation of children's development and learning.

All five students elected to produce a second concept map rather taking the other options of writing, listing or outlining.

Results

The concept maps, pre and post, produced by the five students were qualitatively analyzed. Overall, the final concept maps were markedly clearer than the same individual's pre-maps in regard to hierarchial structure and interrelationships. Examples of a pre-map and a post-map of one of the students (designated as Student A below) are shown in Figures 1 and 2.

Insert Figures 1 and 2 about here

There were wide individual differences on both pre-maps and post-maps. Exposure to the same materials and experiences during the seminar lead to less homogeneity in the ways individuals represented their concepts than was anticipated. The individual differences are qualitatively analyzed in the following case descriptions.

Student A initially produced a very sparse pre-map. On one line the word tests was written which then branched into three items--skill, written and oral. Two of these "streams" (lines leading outward from the central content label--documentation) seemed quite irrelevant to the topic. At the end of the course, this students' post-map was far more differentiated. As an example, one stream had five branches and two of these had even further levels of sub-branching. All were highly relevant. There was no doubt that this students' conceptualization of this topic, as evidenced by the contrast between pre-map and post-map, had become more differentiated and complex as a result of her summer experiences.

Student B, in contrast to Student A, entered the seminar with a rich set of concepts on documentation drawn from prior coursework. The initial map appeared very complex. Much of it, however, was concerned with documentation for purposes of determining program effects as they persisted across time. For example, one stream was labeled correlates to later society development which branched into items of future employment, continuation of education, criminal conviction, etc. While

Figure 1

Student A's Pre-map on "Documentation"

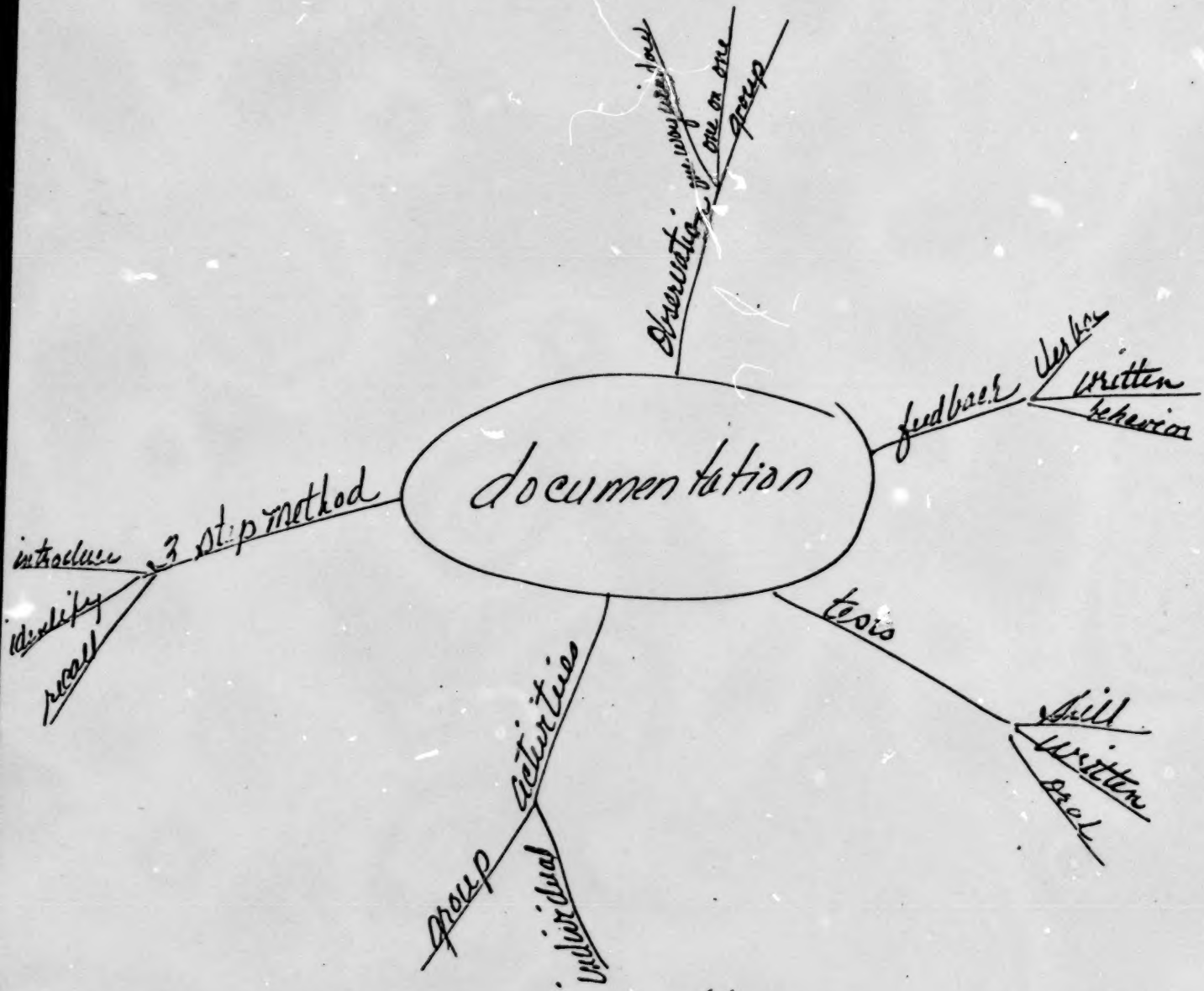
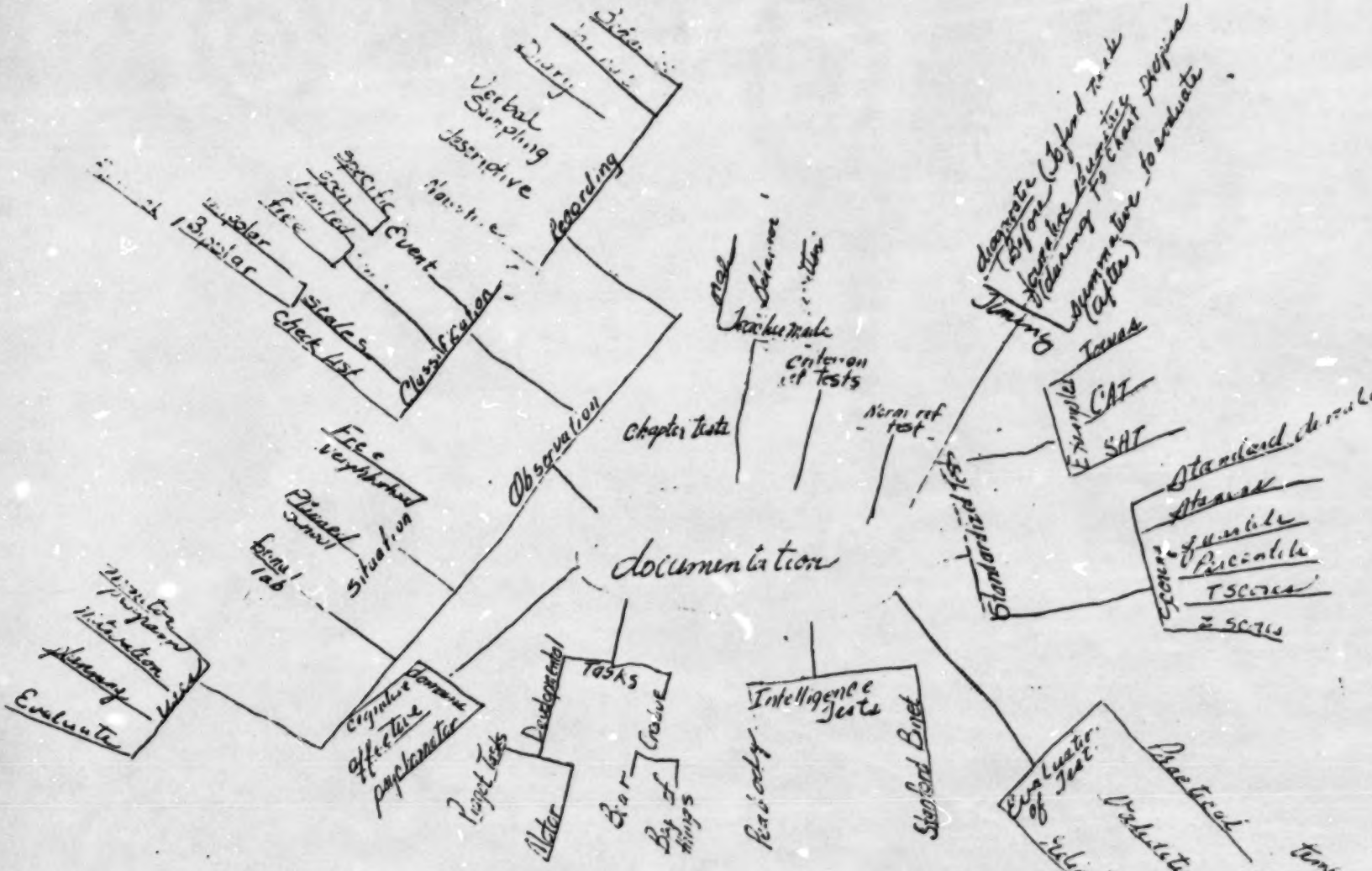


Figure 2

Student A's Post-map on "Documentation"



the concept map seemed to reflect the student's awareness of the context and purposes of documentation only one stream of twelve items was concerned with alternatives for the actual documentation process.

The post concept map drawn by Student B was quite different from the pre. One stream labeled "reasons for documentation" had ten items at the next level. One of these items was "evaluation of program effectiveness," the topic which had been almost the entire focus of the pre-map. In Werner's (1978) terminology, there was both horizontal and vertical differentiation.

Student C, a practicing teacher, produced a pre-map which reflected the practical tasks of classroom testing and the school's traditional testing program. One item stream was achievement testing with names of specific standardized achievement tests as its branches. Another was labeled methods with items of written, oral, auditory, visual. An item stream called materials lead into a listing of such items as papers (tests), pencils, pens, tape recorders, tapes, head phone. The post-map was qualitatively at a higher level of abstractness, reflecting considerable learning. One item stream was entitled type of instrument with sub-streams of norm-referenced, criterion-referenced, observation. Another stream was entitled purposes of instruments. The post-map showed much more sophistication about documentation than the pre-map.

Student D's initial concept map appeared sparse but, unlike some of the other pre-maps, included the same genre of concepts the instructor had scheduled for inclusion in the course of study. The post-map reflected increased differentiation developed through the course experience. The post-map was, however, also somewhat differently or-

ganized than the pre-map. In the pre-map the five item streams were not easy to interpret in a meaningful way. They were labeled hypotheses, testing measures, research studies, testing of persons, observation. In the post-map the streams were developed according to who would be doing documentation. There was one for physicians or psychologists, one for parents, one for teachers. The overall post-map was representative of this student's interest in becoming involved as a psychometrist within a social service agency.

Student E's pre and post maps were very different from the other students. One reason was that the student seemed to interpret the task as requiring flow-charting. The maps, both pre and post, represented more process emphasis than was the case with the other students. This student's pre-map was complex but highly convoluted and unclear. The post-map had only two streams of items leading from the central concept but a clearer decision process sequence. In other classroom activities as well it seemed that this student's focus was more on clarifying and linking the wide array of facts and ideas he appeared to have acquired at some prior point so as to have access to them to make them more usable. Although there was evidence of increased differentiation (added items) and the deletion of some pre-items which might best be described as "noise," the most striking changes were in clarity of organization and intra-map connections.

The five sets of maps, presented in pairs to two judges, were quickly identified by both as to which was pre and which post. The clearer organization and increased vertical differentiaiton of the post maps were not difficult to discern.

Discussion

The concept map goes beyond assessing the student's knowledge at the recognition level; it demands recall and, further, the placement of that which is recalled within a meaningful graphic representatation. What is placed on the concept map appears to directly reflect the student's frame of reference, and, thus, may serve well as a diagnostic device or as a measure of concept acquisition resulting from instruction. For each student in the seminar, for example, it was possible to draw inferences about the nature and extent of changes from examining the pre and post maps. Positive changes were obvious in each case yet the mapping products were quite unique to the particular individual.

Study II

The intent of Study II was to investigate whether differences in educational level and professional experience would be reflected in quantitative measures derived from respondents' concept maps. In addition, we addressed the question of whether instructors' rankings of students' performance in education course would be related to the scores derived from concept maps on the general topic of "teaching."

Subjects

Fifty-six students enrolled in education courses comprised the sample. They were at three different levels--novice undergraduates in an introductory course on study of teaching (N=15), advanced undergraduates in a social studies methods course (N=18), and inservice experienced teachers in a graduate level course on thinking skills (N=20). Subjects at all three levels represented a variety of majors or subspecialities. The novice undergraduate group consisted primarily of

freshmen or sophomores taking their first education course. The social studies methods group were elementary education majors all of whom had completed a number of education courses with related elementary school-based experiences. The in-service teachers were in such areas as elementary, secondary, art, music. Their mean years of teaching experience was approximately 11, (standard deviation 6.6), and the range was from one to 25 years. All subjects participated in the concept mapping activity as part of their regular course involvement.

Procedure

In each of the three courses the instructor (in one instance one of the investigators was the course instructor) gave a brief chalkboard illustration of the process of concept mapping for the concept "math" and then introduced the activity by distributing 8½ by 11 inch sheets with the word "teaching" encircled in the middle of the page and with the following written directions:

NOTE

> Please complete the concept map below to illustrate your current conception of the components of teaching. Let your thoughts flow freely, pursuing details under a general category, until you lose interest and a new general category suggests itself. You may indicate connections between ideas with connecting lines.

The activity was initiated toward the end of the class period. There was no time limit although it was suggested that the activity might take five to ten minutes. All students easily completed their "maps" within that time range.

Methods of Scoring

Number of items. Following Lewin's (1951) definition that "the degree of differentiation of a whole can be defined as the number of its cells (p. 119), a differentiation score was obtained for each individual's cognitive map by simply counting the number of separate items (discrete words or phrases) clustered around the concept of "teaching" regardless of placement in relation to the other items. Thus, in Figure 3, the number of items was determined by count to be 40 and this count constituted the score. Reliability between two independent scorers was very high (Peason r=.99).

Insert Figure 3 about here

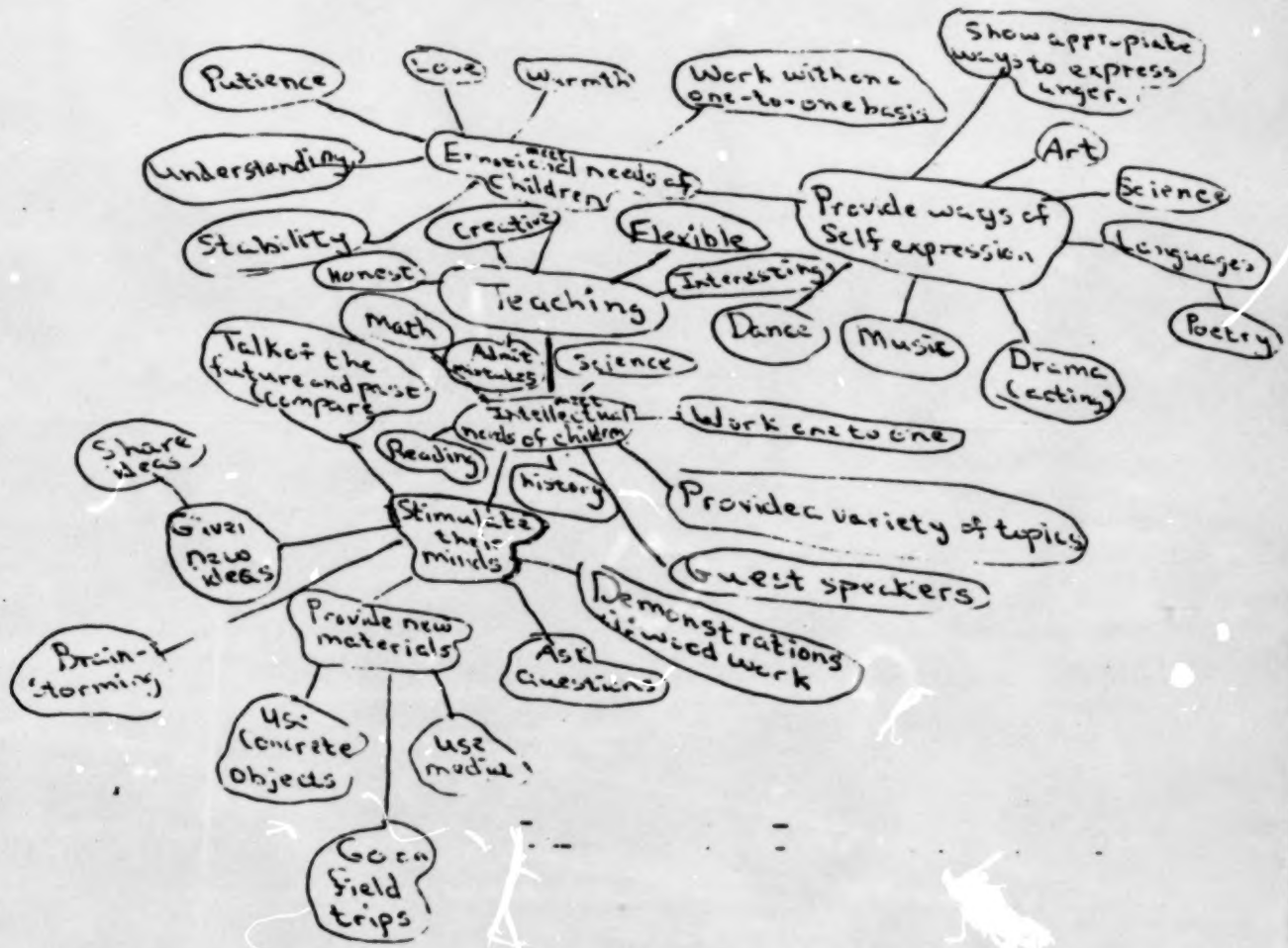
Number of Levels. The number of levels on the concept map were also counted in an attempt to obtain information about hierarchial organization. Levels were defined as the number of subsumed categories in any of the item hierarchies as portrayed by lines drawn outward from the stimulus word. Each level was counted whether or not there was multiple branching at any juncture. Only very obviously redundant or parallel items were not given credit in the scoring. Credit was given for each entry graphically portrayed as a new level whether or not the entry seemed logical to the scorer. In the example in Figure 4 the score for number of levels was four. The two independent scorers were found to have a reliability level of .80 as determined by Pearson correlation.

Number of Item Streams. The third score derived from each map was

Figure 3

Example of Student's Map on "Teaching"

Directions: Please complete the cognitive map below to illustrate your current conception of the components of teaching. Let your thoughts flow freely, pursuing details under a general category, until you lose interest and a new general category suggests itself. You may indicate connections between ideas with connecting lines.



a simple count of item streams. Each line drawn out from the central concept word was counted as an item stream if it lead to one or more words or phrases. In Figure 4 there are seven item streams. Independent scorers had nearly perfect agreement on this count.

The course instructors were asked to rank-order the students in their respective clases on the basis of their course performance.

Results

The means, standard deviations and ranges for number of items, number of levels, and number of streams are presented in Table I for the three groups, along with F's on the differences between groups.

Insert Table I about here

Significant differences were found between the three groups on the number of items included in concept maps; $F(2,53)=14.72$ $p<.0001$. Duncan's Multiple Range Test determined that the experienced teacher group had a significantly higher number of items than either of the undergraduate groups and that the advanced undergraduates were significantly higher than the novice group.

Signifcant differences were also found between the three groups on number of levels included in concept maps; $F(2,53)=3.88$, $p<.03$. The Duncan Multiple Range test found significant differences between experienced teachers and the undergraduate groups but not between two undergraduate groups. There were not, however, significant differences between groups on the number of item streams.

Table 1
Summary Statistics: Study II

	Novice UG (N=18)	Advanced UG (N=18)	Experienced Teachers (N=20)	F(2,53)
Number of items				
Mean	21.72	31.28	41.70	
S.D.	9.98	10.38	15.19	14.72
Range	7-30	9-53	13-70	$p < .0001$
Number of levels				
Mean	2.89	3.17	3.70	
S.D.	.58	.86	1.17	3.88
Range	2-4	2-5	2-6	$p < .03$
Number of item streams				
Mean	5.11	5.61	5.5	
S.D.	2.44	2.38	2.5	.23
Range	1-10	3-11	2-11	n.s.

The Pearson correlation between the dimensions of concept mapping under consideration--number of items and number of levels was .34 ($p < .009$); the correlation between number of items and number of streams was .32 ($p < .01$); the correlation between number of levels and number of streams was -.18(n.s.).

Relationships analyzed with Spearman rho correlations between instructor ranking of students on overall course performance and the students' scores for number of items, number of levels, number of streams were not found to be significant for any of the three groups. Nor were significant relationships determined via Pearson correlates between number of years of teaching within the inservice graduate group and the three types of scores derived from the concept maps: number of items ($r = .33$, n.s.), number of levels ($r = .02$, n.s.), number of item streams ($r = .00$, n.s.).

Discussion

According to the findings of Study II, groups with differing amounts of relevant educational exposure were significantly different in two of the scores derived from concept maps for the global topic "teaching": number of items and number of levels. These differences would seem to reflect the increasing differentiation of concepts and the overall hierarchial complexity gained as a function of individual histories. While it is possible that such differences are simply a function of maturation and are accrued with increasing age, this seems unlikely. More years of experience within the experienced teacher group appears not to have necessarily resulted in more differentiated or hierarchially more complex concept maps. The nature of specific

experiences in interaction with personological variables would seem more likely to be explanatory of individual differences in concept mapping than maturation or longevity of experiences per se.

There was not a relationship for any of the groups between instructor ranking and the concept mapping scores. The topic "teaching" was a global one which may not necessarily correspond to the students' mastery, or lack thereof, of specific concepts introduced within the courses. This comparison cannot be construed as adequately answering the question of whether scores derived from concept maps reflect competence as assessed by other indices.

Inspection of individual protocols revealed great individual variation, even within groups, both in the overall categories included on concept maps and in specific item contents. While there was some evidence of recent course content effects, this was less than might be expected and the variation within as well as across groups was far more striking than the similarities. The differences in overall scores between individuals seemed to be due to ability (or inclination) to identify and elaborate personally idiosyncratic "schemas." The students did not produce maps which reflected a publicly-shared and learned framework, similar to one's instructor or one's peers. If the maps obtained in this study are, as conjectured, direct reflections of students' conceptual structures and semantic memory schemas, one is greatly struck by their variability and idiosyncratic nature.

Study III

Study III addressed two major questions: (1) To what extent do students' concepts of a general concept area, as assessed on a concept

map, remain constant across time? and (2) To what extent does instructional intervention alter students' quantitative scores on concept maps for a content area which is the focus of instruction?

Subjects

Subjects were undergraduate students from two sections on an introductory education course. Both sections were taught by the same instructor.

Procedure

During a class session, students were shown two examples of concept maps by one or the other of the two investigators and the process of concept mapping was explained. The examples were highly differentiated ones, projected from transparencies prepared in advance on topics of "cooking" and "cabin instruction." Directions, identical to those used in Study II were read and 8½ x 11" sheets on which directions were included were distributed. Approximately half of the students in each of the two sections were randomly assigned to complete a concept map on "teaching" and the other half were asked to complete a concept map on "classroom management." The students were told that their performance on the maps would not be shared with their instructor and would not affect their grades. Students in both classes took as much time as they wanted; many continued for as long as twenty minutes.

The curriculum focus in both sections during the following three weeks was on classroom management. At the end of that period, each student was again asked to prepare a concept map on the same topic to which they had been previously assigned--either "teaching" or "classroom management." In constrast to the first study, they were not given

their first map to use as a reference. Students were again told that the maps would not be used in their course evaluation by their instructor.

Only students who were in attendance on both occasions, thus producing both a pre and a post map were included in the study. This resulted in 12 students who had produced "classroom management" maps and 13 who had produced "teaching" maps.

Scoring

Maps were scored according to the procedures described for Study II.

Results

Means, standard deviations and ranges for number of items, levels and streams are presented in Table 3 along with the results of paired

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Insert Table 2 about here

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comparisons of pre-post change scores. The students who mapped "classroom mangement" had significant gains on total number of items ($t=2.88$, $p<.01$) and approach significance on gains for number of levels and streams. For those who prepared maps on "teaching," there were significant decreases on number of streams ($t=-3.59$, $p<.004$) and a near significant decrease on number of items.

Correlations between individuals' pre and post maps on "teaching" were .73($p<.004$) for items, .21 (N.S.) for level and .75($p<.003$) for streams.

Further examination of the pre and post maps of individuals lead to the following observations:

Table 2
Summary Statistics: Study III

	Topic: Classroom Management (N=12)		Topic: Teaching (N=13)	
	Pre	Post	Pre	Post
Number of items				
Means	41.58	57.66	45.30	38.77
S.D.	8.55	22.52	16.46	14.32
Range	22-59	29-110	25-79	19-70
t		2.88(p<.02)		-2.08(p<.06)
Number of levels				
Means	3.83	4.92	4.15	3.84
S.D.	.83	1.38	.99	.90
Range	3-5	3-8	3-6	2-5
t		2.11(p<.06)		-.94(p<.37)
Number of item streams				
Means	4.67	5.50	6.38	5.15
S.D.	1.37	2.19	1.85	1.63
Range	3-8	3-10	4-11	3-9
t		1.97(p<.07)		-3.59(p<.004)

For the students whose maps were done on the global topic of "teaching", there were many changes, pre to post, in the superordinate concepts used. Although each individual's post map had greater similarity to that individual's pre-map than to the maps prepared by other students, there were also a large number of shifts. Nearly all of the students used "new" concepts for at least half of their post-map superordinate concepts. Only 30% of the terms which appeared as superordinate concepts on post-maps had been used by that same individual in any portion of the pre-map.

Students who prepared their maps on "classroom management" were somewhat more constant in the use of concepts. Approximately 40% of the superordinate concepts appearing in pre-maps, reappeared on the same individual's post-map. They too, however, exhibited considerable variation from pre to post and especially between individuals in regard to specific content. The gains, determined from counts of number of items, appeared to be due to both increased vertical differentiation and the addition of new superordinate streams.

Discussion

This study failed to establish that concept mapping may be viewed as a highly reliable measure. Although there was moderate constancy on two of the three quantitative measures for the concept maps on teaching, examination of the internal content showed considerable variation. By contrast, the more specific topic, "classroom management", evidenced somewhat greater content stability, despite the instructional intervention and demonstrated increase in number of items.

We conjecture that, at least for global topics, a concept map prepared at any one point in time, represented only a portion of the respondent's cognitive content regarding that topic. Repeated efforts, on later occasions, may be expected to draw on other relevant associations with the result that new superordinate concepts appear and prior ones are deleted. There is little evidence to suggest that individuals are capable of or sufficiently motivated to represent the full scope of their associations to a global area in any single attempt at mapping. This is probably especially likely to be the case when there is no compelling reason for doing so, e.g., no concern with course evaluation. In this study, the decreases in number of streams from pre to post for the topic "teaching" may reflect students' lack of motivation for doing a second concept map on a topic which had not been the focus of instruction and, since it had been done before, had little novelty appeal.

On the other hand, students' gain in number of items appearing on "classroom mangement" post-maps suggests that concept mapping does reflect increased knowledge resulting from instructional intervention. And, this appeared to be the case even though the students knew that the maps would not be used as a grading device by their instructor.

Study IV

The questions posed in Study III were readdressed in Study IV with some methodological variations.

Subjects

Seven students, including two seniors and five Master's students from an early education methods course were the subjects of this study.

Procedure

During a class session at the beginning of a unit of study on "Providing music experiences for young children", each student was asked to prepared two concept maps--one on the unit topic and the other on a related topic, "Providing art experience for young children." The same verbal directions as in prior studies were given and an illustrative concept map drawn on the chalkboard by one of the investigators (also the course instructor) for the topic, "Careers in Early Education." Sheets (12" x 20") were distributed and ample time given for the preparation of the two maps. The range of time spent was from 20 to 30 minutes.

At the end of the unit of instruction, three weeks later, the student were again asked to prepare concept maps on the same two topics. They were told that the maps would be used by the instructor in evaluating their learning in the music area and to further assess their knowledge regarding "art," the next topic to be studied. While preparing these second set of maps, they did not have access to their first efforts. However, upon completion, they were invited to compare the two sets and six of the seven students elected to do so.

Results

For each of the three types of scores, paired comparisons were made for the students' pre and post maps. The summary data, including means, standard deviations and ranges, are presented in Table 4. There was

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Insert Table 3 about here

Table 3
Summary Statistics: Study IV

	Topic: Music		Topic: Art	
	Pre	Post	Pre	Post
Number of items				
Means	31.71	51.00	40.14	35.28
S.D.	19.09	20.27	15.25	10.31
Range	18-73	23-86	18-60	24-47
t	3.77(p<.009)		-.90(n.s.)	
Number of levels				
Means	2.85	3.71	3.29	4.14
S.D.	.69	1.49	.49	1.46
Range	2-4	3-7	3-4	1-3
t	1.87(n.s.)		1.55(n.s.)	
Number of item Streams				
Means	6.42	2.44	6.85	5.71
S.D.	6.86	2.79	4.06	3.77
Range	2-9	3-11	2-12	2-13
t	.48(n.s.)		-.88(n.s.)	

statistically significant change from pre to post on the "music" maps in regard to number of items ($t=3.77$, $p<.009$). There were not significant effects on number of levels or number of streams. The scores for number of items, number of levels and number of streams were found to be quite stable for the "art" maps. The correlation between pre and post scores for number of items for "art" was .76($p<.05$) in contrast to number of items for music ($r=.42$, n.s.).

Discussion

Although the number of subjects in each of the four studies in this series is small, there is sufficient regularity across studies to suggest that the findings are valid. We are now able to address the question of whether concept maps have regular features from which reliable measures of differentiation or structural organization may be derived. The answer appears to be that there is at least one such regular feature--the number of items. In each of the three quantitative studies, number of items has been found to discriminate between levels of training or instructional intervention. This measure of differentiation has proven to be reliably derived from concept maps and to be a sensitive change measure. This finding may be an important one. What the count of total number of items may be reflecting is the individual's repertoire of concepts. This is a line of research in which the first author has been simultaneously pursuing (Lay-Dopyera and Dopyera, manuscript in preparation).

The other quantitative measures have been far less consistently aligned with educational level or instructional experience. While the content of superordinate constructs and the arrangement of levels and

streams appear to be very useful as diagnostic devices, our attempts at using number of levels or number of streams as quantitative indicators of individual gains from instruction have proven successful in only one instance (number of levels in Study II).

In the studies we have conducted to date, we have not yet adequately addressed the issue of whether either the number of items score or the qualitative appraisals of concept maps are reflecting competence as assessed by other indices. Our attempt to look at this in Study II did not seem well-conceived due to the very general nature of the topic for which mapping was done. Further research along this line is needed. Also further studies are needed on the extent to which concept maps on topics of varying degrees of comprehensiveness remain stable from one mapping effort to the next. In conducting these studies, methodology will be required to address the motivational problem of respondents recording only a minimal aspect of what they are able to think of regarding an assigned topic. There are clearly a number of unanswered questions.

In sum, however, our work to date reinforces Novak's claims that concept mapping is a viable means for determing what information individuals have readily available in memory regarding particular topics. We learn what the student can reconstruct from memory without prompts. This kind of testing certainly contributes more directly and more constructively to our understanding of the instructional and learning tasks than traditional psychometrics.

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